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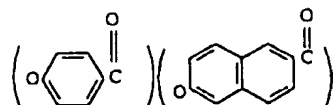
CN1238355 (reference document 1)

Claims

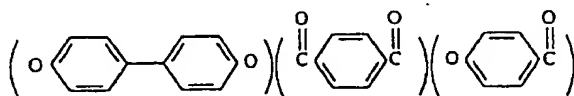
1. A process for preparing polytetrafluoroethylene composites reinforced by liquid crystals polymers, characterized in that said process comprises the following steps:

(1) Adding 10-30% by weight of liquid crystals polymers and 0-10% by weight of glass fiber or calcium carbonate particles into 60-90% by weight of fluoropolymers serving for raw materials, wherein the crystals polymers are high molecular compounds of aromatic polyesters, characterized in that the molecular chain contains any of the following structural units,

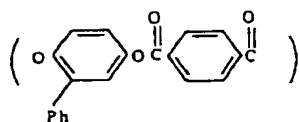
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and pulverizing the liquid crystals polymers to particle sizes smaller than 500 μm by low temperature pulverization for use.

(2) Placing the above mechanically mixed material into a drying box, drying at 135-150°C for 2-10 h, slowly pressurizing to 50-70 MPa after taking out, and maintaining for 3-5 min to complete pre-molding.

(3) Sintering the pre-molded material by raising the temperature in a rate of 2°C per minute, maintaining it at a constant temperature between 310°C and 320°C for 0.5-1 hour, heating to a temperature between 365°C and 380°C in a rate of about 1°C per minute and maintaining for 50-100 minutes, and then cooling to a temperature between 310°C and 320°C and maintaining for 20-30 min, and then cooling to ambient temperature along with the furnace, yielding the composite product.

A process for preparing polytetrafluoroethylene composite reinforced by liquid crystals polymers

The present invention relates to a process for preparing polytetrafluoroethylene composites reinforced by liquid crystals polymers and belongs to the technical field of macromolecular materials.

Polytetrafluoroethylene (abbreviated as PTFE below) is an excellent solid self-lubricating material but has a protruding shortcoming of high wear rate, and therefore filling modification is generally required for application as a sealant. A common method is to add an inorganic filler such as glass fiber, carbon fiber, tin bronze powders, or molybdenum disulfide, but such filler-modified products still have shortcomings of poor compatibility and affinity between the inorganic filler and PTFE, resulting in the appearance of obvious interface inside the substrate, difficulty to uniformly disperse, and severe damage to the pulverized elements.

The inventor has discovered that under identical experimental conditions, modification by ordinary methods has the following effects relative to pure PTFE: addition of 15% of glass fiber and 5% of graphite enhances the abrasability of PTFE by 23 times, addition of 60% of bronze powders enhances the abrasability of PTFE by more than 8 times, and the abrasability of the PTFE composite with the most modification effect containing a mixture of glass fiber, bronze powders, and graphite is enhanced by only 36 time.

The liquid crystal polymer (LCP) is a unique member of the polymer family and has prominent comprehensive properties. In view of the application, it is mainly classified into two large categories, namely, dissolution-induced liquid crystal exhibiting the liquid crystal phase in the dissolution state and thermo-induced liquid crystal (TLCP) exhibiting the liquid crystal phase in the melt state. It has been discovered that LCP can play a greatest in-situ composite enhancing role due to the high orientation of the rigid rodlike structure in the molecular chain resulted from the forces of extrusion, injection molding, and stretching, etc. However, very few

researchers make attempts to reinforce the resins molded by die pressing by using liquid crystals and examine the in-situ enhancing effect of LCP under no action of stretching, extruding, etc.

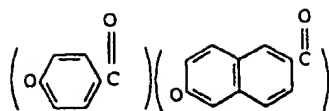
The objective of the present invention is to develop a process for preparing PTFE composites reinforced by LCP to greatly improve their abrasability while retain the self-lubricant property, and possibly make them become candidate materials for sealing elements with high strength and high abrasability. Flow orientation arrangement happens with the thermo-induced liquid crystal (TLCP) used in the present invention and microfibrillar structure enhancing phase partly forms in situ inside the substrate, thereby achieving the object of improving the abrasability.

The process designed by the present invention for preparing PTFE composites reinforced by LCP comprises the following steps:

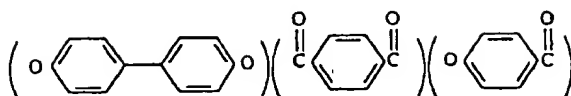
1. The present invention is a filled fluoropolymer-based composite, the recipe is adding 10-30% by weight of LCP and 0-10% by weight of glass fiber or calcium carbonate particles into 60-90% by weight of fluoropolymers serving for a major component. It should be noted that the adverse effect on the pulverized parts is limited to a very small extent when the percentage of glass fiber or calcium carbonate particles added here is lower than 10%, and thus not only the effect of the improvement in the abrasability is retained, but also the cost is lowered.

The aforesaid LCP is a macromolecular compound of the aromatic polyester, characterized in that the molecular chain contains one of the following structural units. These LCP belong to high-heat LCP with high melting points, so they can meet the requirement for mixing with PTFE and high-temperature sintering, and have certain compatibility.

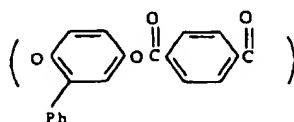
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pulverizing the aforesaid liquid crystals polymers to particle sizes smaller than 500 μm by low temperature pulverization for use. They are irregular particulate powders before use. The low temperature pulverization proceeds by cooling with liquid nitrogen and the purpose is to prevent the physical properties of the LCP from varying, thereby erasing its advantages of high strength and thermotolerance.

2. Placing the above mechanically mixed material into a drying box, drying at 135-150°C for 2-10 hours, slowly pressurizing to 50-70 MPa after taking out, and maintaining for a certain duration according to the size of the sample, generally 3-5 minutes to proceed pre-molding.

3. Sintering the pre-molded material by raising the temperature in a rate of 2°C per minute, maintaining at a constant temperature between 310°C and 320°C for 0.5-1 hour, raising the temperature to 365-380°C in a rate of 1°C per minute, maintaining at a constant temperature between 365°C and 380°C for 50-100 minutes, and then cooling to 310-320°C and maintaining for 20-30 min, and then cooling to ambient temperature along with the furnace, yielding the composite product.

The examples of the present invention will be described bellow:

To carry out the experiments, Xydar serial LCP products, Vectra serial LCP products, and Zenite LCP products were purchased from Amoco

Chemicals Corp., Tinoca Co., and E. I. du Pont de Nemours & Co. respectively, and the fluoropolymer is a suspended PTFE resin produced in Jinan Chemicals Plant

Example 1

20% of powders of 100-300 μm derived by pulverizing Vectra C550 (50%A+50% mineral particles) were mixed with 80% of PTFE, and the mixture was dried at 150°C for 4 hours and then pressurized at 70 MPa for 3 minutes. Sintering was carried out by first maintaining it at a constant temperature between 310°C and 320°C for 30 minutes, and then heating to 365°C and maintaining for 70 minutes. The sample was derived after cooling to 310°C-320°C and maintaining for 25 minutes, and then cooling together with the furnace. The sample was subjected to the GB3160-83 friction wear testing at a load of 10 kg and a rate of 200 rpm for 2 hours, and an average value from 3-4 times experiment data was calculated. The experiment results were that the friction coefficient was 0.192 and the wear rate was $1.92 \times 10^{-6} \text{ mm}^3/\text{kg}/\text{m}$, while the wear rate of pure PTFE was $497 \times 10^{-6} \text{ mm}^3/\text{kg}/\text{m}$ under the same friction wear testing conditions, namely, the abrasability of the sample of this example was raised by 259 times.

Example 2

20% of powders of 100 μm derived by pulverizing Vectra C550 (50%A+50% mineral particles) were mixed with 80% of PTFE, and the mixture was dried at 150°C for 5 hours, and then pressurized at 65 MPa for 5 minutes. Sintering was carried out by first maintaining at a constant temperature between 310°C and 320°C for 30 minutes, and then heating to 365°C and maintaining for 60 minutes. The sample was derived after cooling to 310°C-320°C and maintaining for 20 minutes, and then cooling together with the furnace. The sample was subjected to the GB3160-83 friction wear testing under identical conditions as Example 1. The experiment results were that the friction coefficient was 0.204 and the wear rate was $1.01 \times 10^{-6} \text{ mm}^3/\text{kg}/\text{m}$, namely, the abrasability of the sample of this example was raised by about 490 times relative to pure PTFE.

Example 3

A powder material containing 30% of A was derived by pulverizing A into below 200 μm and then mixing with 70% of PTFE. The mixture was dried at 150°C for 6 hours, and then pressurized at 65 MPa for 5 minutes. Sintering was carried out by first maintaining the mixture at a constant temperature between 310°C and 320°C for 30 minutes, and then heating to 365°C and maintaining for 50 minutes. The sample was derived after cooling to 310°C-320°C and maintaining for 20 minutes, and then cooling together with the furnace. The sample was subjected to the GB3160-83 friction wear testing under identical conditions as Example 1. The experiment results were that the friction coefficient was 0.196 and the wear rate was $1.38 \times 10^{-6} \text{ mm}^3/\text{kg}/\text{m}$, namely, the abrasability of the sample of this example was raised by about 360 times relative to pure PTFE.

Example 4

30% of powders of 100-300 μm derived by pulverizing Xydar G930 (containing 70% of B and 30% of glass fiber) were mixed with 70% of PTFE. The mixture was dried at 150°C for 10 hours, and then pressurized at 60 MPa for 5 minutes. Sintering was carried out by first maintaining the mixture at a constant temperature between 310°C and 320°C for 45 minutes, and then heating to 370°C and maintaining for 80 minutes. The sample was derived after cooling to 310°C-320°C and maintaining for 25 minutes, and then cooling together with the furnace. The sample was subjected to the GB3160-83 friction wear testing under identical conditions as Example 1. The experiment results were that the friction coefficient was 0.224 and the wear rate was $2.92 \times 10^{-6} \text{ mm}^3/\text{kg}/\text{m}$, namely, the abrasability of the sample of this example was raised by about 170 times relative to pure PTFE.

Example 5

20% of powders of below 100 μm derived by pulverizing Xydar G930 (containing 70% of B and 30% glass fiber) were mixed with 80% of PTFE. The mixture was dried at 150°C for 8 hours, and then pressurized at 60 MPa for 4 minutes. Sintering was carried out by first maintaining the mixture at a constant temperature between 310°C and 320°C for 50 minutes, and then heating to 375°C and maintaining for 80 minutes. The sample was derived

after cooling to 310°C-320°C and maintaining for 30 minutes, and then cooling together with the furnace. The sample was subjected to the GB3160-83 friction wear testing under identical conditions as Example 1. The experiment results were that the friction coefficient was 0.219 and the wear rate was 2.30×10^{-6} mm³/kg/m, namely, the abrasability of the sample of this example was raised by about 216 times relative to pure PTFE.

Example 6

30% of powders of below 150 μm derived by pulverizing Xydar G900 (100% of B) were mixed with 70% of PTFE. The mixture was dried at 150°C for 9 hours, and then pressurized at 60 MPa for 3 minutes. Sintering was carried out by first maintaining the mixture at a constant temperature between 310°C and 320°C for 40 minutes, and then heating to 365°C and maintaining for 60 minutes. The sample was derived after cooling to 310°C-320°C and maintaining for 30 minutes, and then cooling together with the furnace. The sample was subjected to the GB3160-83 friction wear testing under identical conditions as Example 1. The experiment results were that the friction coefficient was 0.207 and the wear rate was 1.73×10^{-6} mm³/kg/m, namely, the abrasability of the sample of this example was raised by about 287 times relative to pure PTFE.

Example 7

30% of powders of 100-300 μm derived by pulverizing Zenite 6130 (containing 70% of C and 30% of glass fiber) were mixed with 70% of PTFE. The mixture was dried at 135°C for 3 hours, and then pressurized at 55 MPa for 3 minutes. Sintering was carried out by first maintaining the mixture at a constant temperature between 310°C and 320°C for 60 minutes, and then heating to 380°C and maintaining for 100 minutes. The sample was derived after cooling to 310°C-320°C and maintaining for 30 minutes, and then cooling together with the furnace. The sample was subjected to the GB3160-83 friction wear testing under identical conditions as Example 1. The experiment results were that the friction coefficient was 0.222 and the wear rate was 1.85×10^{-6} mm³/kg/m, namely, the abrasability of the sample of this example was raised by 268 times relative to pure PTFE.

Example 8

20% of powders of 300-500 μm derived by pulverizing Zenite 6130 (containing 70% of C and 30% of glass fiber) were mixed with 80% of PTFE. The mixture was dried at 135°C for 2 hours, and then pressurized at 50 MPa for 4 minutes. Sintering was carried out by first maintaining the mixture at a constant temperature between 310°C and 320°C for 60 minutes, and then heating to 380°C and maintaining for 90 minutes. The sample was derived after cooling to 310°C-320°C and maintaining for 30 minutes, and then cooling together with the furnace. The sample was subjected to the GB3160-83 friction wear testing under identical conditions as Example 1. The experiment results were that the friction coefficient was 0.228 and the wear rate was $1.52 \times 10^{-6} \text{ mm}^3/\text{kg}/\text{m}$, namely, the abrasability of the sample of this example was raised by 327 times relative to pure PTFE.

For comparison, GB3160-83 testing was made under the identical conditions of a load of 5 kg and a rate of 200 rpm on pure PTFE and PTFE doped with ordinary inorganic fillers. The results are shown in Table 1.

Table 1 Results on the friction wear testing of the PTFE composites modified with ordinary fillers

Sample	Friction coefficient	Wear rate, $10^{-6} \text{ mm}^3/\text{kg}/\text{m}$
PTFE	0.18	374
PTFE+20%SGF	0.22	20.6
PTFE+40%SGF	0.23	11.6
PTFE+10%LGF	0.21	16.1
PTFE+20%LGF	0.24	17.9
PTFE+20% copper powder	0.25	78.7
PTFE+40% copper powder	0.26	27.7
PTFE+60% copper powder	0.27	12.2
PTFE+5%MoS ₂	0.19	103
PTFE+10%MoS ₂	0.20	67.7

Note: SGF in Table 1 represents short glass fiber; LGF represents long glass

fiber

For clarity, Table 2 compares the times by which the abrasability of various tested materials was raised relative to pure PTFE, namely, the reciprocal of the ratio of the wear rate of the materials to that of pure PTFE under the same conditions.

Table 2 Comparison of the rising times of the abrasability of PTFE modified with liquid crystal and ordinary fillers

PTFE filled with liquid crystal		PTFE modified with ordinary fillers	
Sample	Rising times	Sample	Rising times
Example 1	259	PTFE+20%SGF	18
Example 2	490	PTFE+40%SGF	32
Example 3	360	PTFE+10%LGF	23
Example 4	170	PTFE+20%LGF	21
Example 5	216	PTFE+20% copper powder	5
Example 6	287	PTFE+40% copper powder	13
Example 7	268	PTFE+60% copper powder	31
Example 8	327	PTFE+5%MoS ₂	3
		PTFE+10%MoS ₂	6

It can be seen that, the abrasability of the composites of LCP with PTFE is apparently lowered compared to other filled composites while retaining low friction coefficient. Compared to pure PTFE, the abrasability of Example 2 with the best effect is raised by more than 490 times relative to pure PTFE under identical conditions. Example 4 with the worst effect still raises the abrasability by about 170 times, while the ordinary filler with the best effect only raises the abrasability by 32 times.

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权利要求书 1 页 说明书 5 页 附图页数 0 页

[54]发明名称 一种由液晶类聚合物增强的聚四氟乙烯复合材料的制备方法

[57]摘要

本发明涉及一种由液晶类聚合物增强的聚四氟乙烯复合材料的制备方法,首先以氟聚合物为原料,加入液晶类聚合物和玻璃纤维或碳酸钙颗粒,其中的液晶类聚合物为芳香族聚酯类高分子化合物,将机械混合均匀的材料放置于干燥箱内,干燥后加压,使其预制成型,再进行烧结,即得本发明的复合材料制品。本发明的复合材料在保持聚四氟乙烯的自润滑特征基础上,极大地改善其耐磨性,成为高强耐磨密封件的选用材料。

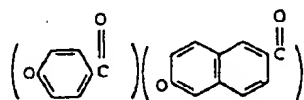
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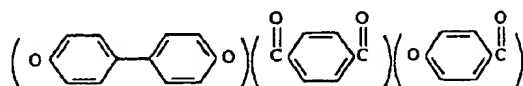
1、一种由液晶类聚合物增强的聚四氟乙烯复合材料的制备方法，其特征在于，该方法包括以下各步骤：

(1) 以重量占 60%~90%的氟聚合物为原料，加入重量占 10%~30%液晶类聚合物和重量占 0~10%的玻璃纤维或碳酸钙颗粒，其中的液晶类聚合物为芳香族聚酯类高分子化合物，其物征是分子链中含有以下结构单元中的任何一种，

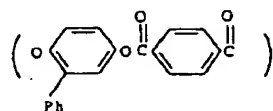
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并将该液晶类聚合物用低温研磨粉碎至小于 500 μm 的粒度使用；

(2) 将上述机械混合均匀的物料放置于干燥箱内，在 135~150°C 下干燥 2~10 小时，取出后缓慢加压至 50~70MPa，保持 3~5 分钟，使其预制成型；

(3) 再以每分钟约 2°C 的速度升温烧结，在 310°C~320°C 间恒温 0.5~1 小时；再以每分钟 1°C 左右的速度升温到 365~380°C 恒温 50~100 分钟，然后冷却至 310°C~320°C 恒温 20~30 分钟，随炉冷却至室温，即得本发明的复合材料制品。



说明书

一种由液晶类聚合物增强的聚四氟乙烯复合材料的制备方法

本发明涉及一种由液晶类聚合物增强的聚四氟乙烯复合材料的制备方法，属高分子材料技术领域。

聚四氟乙烯（以下简称 PTFE）是优良的固体自润滑材料，但其突出的缺点是磨损率大，一般需进行填充改性才可用作密封材料。普遍的作法是在其中填加玻璃纤维、碳纤维、锡青铜粉、二硫化钼等无机填料。但这些填充改性制品仍存在无机填料与聚四氟乙烯相容性差，亲和力较小，在基体中出现明显界面，且不易分散均匀，对被磨件损伤大等不足之处。

相对于纯 PTFE 而言，发明人在同样的实验条件下发现，普通填料改性的方法对耐磨性提高效果为：填加 15% 的玻璃纤维和 5% 的石墨的 PTFE，其耐磨性提高 23 倍，填加 60% 青铜粉的 PTFE，其耐磨性提高 8 倍多，而改性效果最好的含玻纤、青铜粉和石墨混合物的 PTFE 复合材料其耐磨性也才提高了 36 倍。

液晶聚合物（LCP）是聚合物家庭中的独特成员，具有卓著的综合性能。从应用角度来看，不要分为两大类，即溶化状态下成液晶相的溶致液晶和在熔融状态下成液晶相的热致液晶（TLCP）。人们已经发现它们在加工过程中由于受到挤出、注塑、拉伸等力的作用，其分子链中刚性棒状结构会发生高度取向从而极大地起到原位复合增强作用。然而很少有研究者尝试用液晶增强模压工艺成型的树脂，考察在没有受拉伸、挤出等力的作用下液晶聚合物的原位增强效果。

本发明的目的是研究一种由液晶类聚合物增强的聚四氟乙烯复合材料的制备方法，在保持聚四氟乙烯的自润滑特征基础上，极大地改善其耐磨性，使其有可能成为高强耐磨密封件的选用材料。本发明所采用的熔致型液晶（TLCP）在受热的情况下能发生流动取向排列，在基体内部部分原位形成微纤结构增强相，从而达到改善耐磨性的目的。

本发明设计的由液晶类聚合物增强的聚四氟乙烯复合材料的制备方法，包括以下步骤：

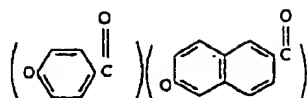
- 1、本发明为一种填充型氟聚合物基复合材料，配方是以重量占 60%~90% 的氟聚合物为主要成份，加入重量占 10%~30% 液晶类聚合物（LCP）和重量占 0~10% 的玻璃纤维或碳酸钙颗粒；需要说明的是，此处所加的玻纤或碳酸钙颗粒的重量百分比在 10% 以内，即对被磨件的不良影响在很小的范围内，却不影响耐磨性改善的效果，又能降低成本。

上述的液晶类聚合物为芳香族聚酯类高分子化合物，其物征是分子链中含的以下结构单元中的一种。这些液晶属高热型 LCP，熔点较高，能满足与 PTFE 共混并高温烧结的要

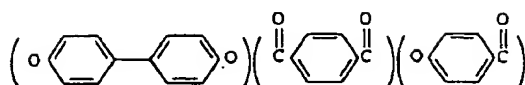


求，且具有一定的相容性。

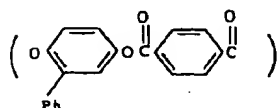
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并将上述的液晶类聚合物，应用低温研磨粉碎至小于 500 μm 的粒度使用。使用前为不规则粒状粉末。低温研磨粉碎用液氮冷却获得，目的是防止液晶的物性发生变化，损害其高强度、耐高温的优点。

2、将上述机械混合均匀的物料放置于干燥箱内，在 135~150 $^{\circ}\text{C}$ 下干燥 2~10 小时，取出后进行压制。缓慢加压至 50~70MPa，视样品大小保压一段时间预制成型，一般为 3~5 分钟；

3、再以每分钟约 2 $^{\circ}\text{C}$ 的速度升温烧结，在 310 $^{\circ}\text{C}$ ~320 $^{\circ}\text{C}$ 间恒温 0.5~1 小时；再以每分钟 1 $^{\circ}\text{C}$ 左右的速度升温到 365~380 $^{\circ}\text{C}$ 恒温 50~100 分钟，然后冷却至 310 $^{\circ}\text{C}$ ~320 $^{\circ}\text{C}$ 恒温 20~30 分钟，随炉冷却至室温，即得本发明的复合材料制品。

下面介绍本发明的实施例：

为进行实验，分别从 Amoco 公司购得 Xydar 系列液晶聚合物产品，从 Tinoca 公司购得 Vectra 系列液晶聚合物产品和从 Dupont 公司购得 Zenite 系列液晶聚合物产品。氟聚合物采用了济南化工厂生产的 PTFE 悬浮树脂。

实施例 1:

将 20%Vectra C550 (50%A+50%矿物颗粒) 粉碎到 100~300 μm 的粉料与 80%PTFE 的物料，在 150 $^{\circ}\text{C}$ 下干燥 4 个小时；压制压力为 70MPa，保压 3 分钟，烧结时在 310 $^{\circ}\text{C}$ ~320 $^{\circ}\text{C}$ 间恒温 30 分钟，再升至 365 $^{\circ}\text{C}$ 恒温 70 分钟；冷却阶段在 310 $^{\circ}\text{C}$ ~320 $^{\circ}\text{C}$ 恒温 25 分钟，再随炉冷却即得试样，进行 GB3160-83 摩擦磨损试验，载荷为 10Kg，速度为 200 转/分，实验进行 2 小时。取 3 至 4 次实验的平均值。实验结果为摩擦系数 0.192，磨损率为 $1.92 \times 10^{-6} \text{mm}^3/\text{Kg/m}$ ；而同样摩擦磨损实验条件下的纯 PTFE 的磨损率为 $497 \times 10^{-6} \text{mm}^3/\text{Kg/m}$ 。即本实例的耐磨性提高了 259 倍之多。

实施例 2:



将 20%Vectra C550 (50%A+50%矿物颗粒) 粉碎到 100 μ m 的粉料与 80%PTFE 的物料, 在 150 $^{\circ}$ C 下干燥 5 个小时; 压制压力为 65MPa, 保压 5 分钟, 烧结时在 310 $^{\circ}$ C~320 $^{\circ}$ C 间恒温 30 分钟, 再升至 365 $^{\circ}$ C 恒温 60 分钟; 冷却阶段在 310 $^{\circ}$ C~320 $^{\circ}$ C 恒温 20 分钟, 再随炉冷却即得试样, 进行 GB3160-83 摩擦磨损试验, 条件同 1)。实验结果为摩擦系数 0.204; 磨损率为 $1.01 \times 10^{-6} \text{mm}^3/\text{Kg/m}$; 比之纯 PTFE 的耐磨性提高 490 倍左右。

实施例 3:

将 A 粉碎到 200 μ m 以下直径的粉料与 PTFE 混合成含 A30%的物料, 在 150 $^{\circ}$ C 下干燥 6 个小时; 压制压力为 65MPa, 保压 5 分钟, 烧结时在 310 $^{\circ}$ C~320 $^{\circ}$ C 间恒温 30 分钟, 再升至 365 $^{\circ}$ C 恒温 50 分钟; 冷却阶段在 310 $^{\circ}$ C~320 $^{\circ}$ C 恒温 20 分钟, 再随炉冷却即得试样, 进行 GB3160-83 摩擦磨损试验, 条件同 1)。实验结果为摩擦系数 0.196, 磨损率为 $1.38 \times 10^{-6} \text{mm}^3/\text{Kg/m}$; 比之纯 PTFE 的耐磨性提高 360 倍左右。

实施例 4

将 30%的 Xydar G930 (含 70%B 和 30%玻璃纤维) 粉碎到 100~300 μ m 的粉料与 70%的 PTFE 混合的物料, 在 150 $^{\circ}$ C 下干燥 10 个小时; 压制压力为 60MPa, 保压 5 分钟, 烧结时在 310 $^{\circ}$ C~320 $^{\circ}$ C 间恒温 45 分钟, 再升至 370 $^{\circ}$ C 恒温 80 分钟; 冷却阶段在 310 $^{\circ}$ C~320 $^{\circ}$ C 恒温 25 分钟, 再随炉冷却即得试样, 进行 GB3160-83 摩擦磨损试验, 条件同 1)。实验结果为摩擦系数 0.224, 磨损率为 $2.92 \times 10^{-6} \text{mm}^3/\text{Kg/m}$; 比之纯 PTFE 的耐磨性提高约 170 倍。

实施例 5:

将 20%Xydar G930 (含 70%B 和 30%玻璃纤维) 粉碎到 100 μ m 以下的粉料与 80%PTFE 混合的物料, 在 150 $^{\circ}$ C 下干燥 8 个小时; 压制压力为 60MPa, 保压 4 分钟, 烧结时在 310 $^{\circ}$ C~320 $^{\circ}$ C 间恒温 50 分钟, 再升至 375 $^{\circ}$ C 恒温 80 分钟; 冷却阶段在 310 $^{\circ}$ C~320 $^{\circ}$ C 恒温 30 分钟, 再随炉冷却即得试样, 进行 GB3160-83 摩擦磨损试验, 条件同 1)。实验结果为摩擦系数 0.219, 磨损率为 $2.30 \times 10^{-6} \text{mm}^3/\text{Kg/m}$; 比之纯 PTFE 耐磨性提高约 216 倍。

实施例 6:

将 30%Xydar G900 (即 100%B) 粉碎到 150 μ m 以下的粉料与 70%PTFE 混合的物料, 在 150 $^{\circ}$ C 下干燥 9 个小时; 压制压力为 60MPa, 保压 3 分钟, 烧结时在 310 $^{\circ}$ C~320 $^{\circ}$ C 间恒温 40 分钟, 再升至 365 $^{\circ}$ C 恒温 60 分钟; 冷却阶段在 310 $^{\circ}$ C~320 $^{\circ}$ C 恒温 25 分钟, 再随炉冷却即得试样, 进行 GB3160-83 摩擦磨损试验, 条件同 1)。实验结果为摩擦系数 0.207, 磨损率为 $1.73 \times 10^{-6} \text{mm}^3/\text{Kg/m}$; 比之纯 PTFE 耐磨性提高约 287 倍。

实施例 7:

将 30%Zenite6130 (含 70%C 和 30%玻璃纤维) 粉碎到 100~300 μ m 的粉料与 70%PTFE 混合成的物料, 在 135 $^{\circ}$ C 下干燥 3 个小时; 压制压力为 55MPa, 保压 3 分钟, 烧结时在



310°C~320°C 间恒温 60 分钟, 再升至 380°C 恒温 100 分钟; 冷却阶段在 310°C~320°C 恒温 30 分钟, 再随炉冷却即得试样, 进行 GB3160-83 摩擦磨损试验, 条件同 1)。实验结果为摩擦系数 0.222, 磨损率为 $1.85 \times 10^{-6} \text{mm}^3/\text{Kg/m}$; 其耐磨性比纯 PTFE 提高了 268 倍。

实施例 8:

将 20%Zenite6130 (含 70%C 和 30%玻璃纤维) 粉碎到 300~500 μm 的粉料与 PTFE 合成的物料, 在 135°C 下干燥 2 个小时; 压制压力为 50MPa, 保压 4 分钟, 烧结时在 310°C~320°C 间恒温 60 分钟, 再升至 380°C 恒温 90 分钟; 冷却阶段在 310°C~320°C 恒温 30 分钟, 再随炉冷却即得试样, 进行 GB3160-83 摩擦磨损试验, 条件同 1)。实验结果为摩擦系数 0.228, 磨损率为 $1.52 \times 10^{-6} \text{mm}^3/\text{Kg/m}$; 其耐磨性比纯 PTFE 提高了 327 倍。

为便于对比, 在同样的实验条件下, 进行了纯 PTFE 及填加一般无机填料的 GB3160-83 实验, 载荷为 5 公斤, 速度为 200 转/分。所得结果如下表所示:

表 1 普通填料改性 PTFE 复合材料摩擦磨损实验结果

试样	摩擦系数	磨损率, $10^{-6} \text{mm}^3/\text{Kg/m}$
PTFE	0.18	374
PTFE+20%SGF	0.22	20.6
PTFE+40%SGF	0.23	11.6
PTFE+10%LGF	0.21	16.1
PTFE+20%LGF	0.24	17.9
PTFE+20%铜粉	0.25	78.7
PTFE+40%铜粉	0.26	27.7
PTFE+60%铜粉	0.27	12.2
PTFE+5%MoS ₂	0.19	103
PTFE+10%MoS ₂	0.20	67.7

说明: 上表中 SGF 代表短玻璃纤维;

LGF 代表长玻璃纤维

表 2 是将各种实验材料的的磨损率与纯 PTFE 在同样实验条件下的磨损率的比值的倒数做为耐磨性提高倍数来进行比较, 以便有一目了然的认识。

表 2 普通填料改性 PTFE 与液晶填充 PTFE 的耐磨性提高倍数对比

液晶填充 PTFE		普通填料改性 PTFE	
试 样	提高倍数	试 样	提高倍数
实 例 1	259	PTFE+20%SGF	18
实 例 2	490	PTFE+40%SGF	32
实 例 3	360	PTFE+10%LGF	23

实例 4	170	PTFE+20%LGF	21
实例 5	216	PTFE+20%铜粉	5
实例 6	287	PTFE+40%铜粉	13
实例 7	268	PTFE+60%铜粉	31
实例 8	327	PTFE+5%MoS ₂	3
		PTFE+10%MoS ₂	6

可见，液晶聚合物与 PTFE 的复合材料在保持了低摩擦系数的同时，磨损率比其它填充型复合材料又有了明显下降。效果最好的实例 2 与同样实验条件的纯 PTFE 相比，耐磨性提高了 490 多倍；而实例中最差的实例 4 也提高了 170 倍左右。而普通填料效果最好的也才提高耐磨性 32 倍之多。